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Evaluation of Mexican American Migrant Farmworker Work Practices and Organochlorine Pesticide Metabolites

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Background *Epidemiologic studies often must rely upon questionnaire data to assess past exposures. The ability of questionnaires to rank migrant farmworkers according to past pesticide exposure is not known.*

Methods *We conducted a pilot feasibility study to measure a panel of 21 organochlorine pesticides (OCPs) and correlate levels with reported occupational exposures in 26 Mexican–American migrant farmworkers in Baytown, Texas. The Migrant Farmworker Questionnaire developed by the National Cancer Institute (NCI) was administered and each participant donated a blood sample. Three OCPs [mean (ppb) levels: mirex 1.8, DDT 1.0, and trans-nonachlor 0.7] were detected despite the fact that these chemicals have been banned in the US for many years, and the detected levels were far higher than the standard provided by the referent laboratory. Work clothes, protective attire, and self-reported pesticide exposures were significant predictors of OCP exposure. Similarly, personal hygiene, length of employment, and number of duties also predicted OCP exposure.*

Conclusions *The results of this study indicate that data obtained from standardized questionnaires may be reasonable indicators of occupational exposure when biomarker data are not available.* Am. J. Ind. Med. 40:554–560, 2001. *© 2001 Wiley-Liss, Inc.*

KEY WORDS: agriculture; migrant farmworkers; Mexican–Americans; adults; Texas; serum levels; organochlorine pesticides; work practices; living conditions; pesticide exposures

INTRODUCTION

Synthetic chlorinated hydrocarbon compounds (organochlorine pesticides (OCPs)) are environmental contaminants that are still prevalent throughout the US, and it has been postulated that they may increase the risk of developing non-Hodgkin's lymphoma [Hoffman, 1996].

Cancer research among farmworkers is almost nonexistent, which is probably the perceived logistical difficulties in conducting epidemiological studies among this underrepresented population. Most agricultural studies have been conducted among farm owners and operators, and not migrant or seasonal farmworkers, even though the latter group is chronically exposed to pesticides and other agricultural exposures, sometimes at a very young age,

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when susceptibility may be of great importance [Zahm and Blair, 1993]. Before conducting full-scale cancer etiologic investigations among farmworkers, several feasibility issues need to be resolved including the use of a standardized questionnaire (*Migrant Farmworker Questionnaire* (*MFQ*)) to obtain lifetime occupational histories from farmworkers and the use of the questionnaire data to impute exposure histories [Zahm and Blair, 1997]. Therefore, we conducted a pilot study among migrant farmworkers to gather epidemiological and occupational data (i.e., sociodemographics, work practices, etc.), and blood to evaluate past OCP pesticide exposures.

METHODS

This pilot study was conducted in Baytown, Texas, from July to August 1998. The aims of the study were: (1) to provide quantitative measures of OCP levels in a panel of 21 chlorinated pesticides in the serum of migrant farmworkers; (2) to obtain occupational and pesticide exposure data from a standardized epidemiological questionnaire; (3) to evaluate the validity of the questionnaire by comparing the occupational and self-reported pesticide exposure data with the OCP metabolites; and (4) to test the feasibility of conducting epidemiological studies among home-based migrant farmworker populations.

In this study, 26 adult MA migrant farmworkers (8 males and 18 females) were recruited through the Migrant Education Program (MEP) in Baytown, Texas. There were no race or ethnic, gender, or age restrictions, the only inclusionary criterion was their occupation: "current or former migrant farmworkers." All participants were of Mexican origin. During the last week of June 1998, the PI (Dr. Hernández-Valero, Principal Investigator) attended a summer school informational meeting for the parents of the migrant farmworker children who were enrolled in the summer school program, and those migrant farmworkers who expressed a willingness to participate were contacted within a few days to schedule a home visit. Only two (7%) of the migrant farmworkers (a married couple) were not able to participate in the study due to the husband's health status (hospitalized with cardiovascular problems on the scheduled date for the home visit). Participants were given food items as a token of appreciation for their participation.

The PI conducted interviews in the participants' home in the language of their choice (Spanish or English) using the standardized bilingual *MFQ* developed by the NCI and the Farmworker Epidemiology Research Group [Zahm and Blair, 1993]. Four sections from the *MFQ* were used in this study: the sociodemographic section which included information on gender, age, education, country of birth, number of years in the US, language spoken, number of months worked per year, and total number of years worked. The other three sections evaluated work practices (number of years worked, number of duties performed, types of clothing and protective wear worn), living conditions (living quarter location, personal hygiene), and self-reported pesticide exposures of farmworkers through pesticide application (frequency of use, contact with containers/ equipment, exposure in the field, home use). We used a Likert-type scale (*never, seldom, half of the time, most of the time, always*) to evaluate current and past living conditions and self-reported pesticide exposures. We also measured the participants' weight and the height to calculate the body mass index (BMI) as weight in kg/height^2 in meters [Frankel, 1986] because OCPs are stored in adipose tissue where they remain sequestered for long periods of time after exposure and are released into the blood serum where they can be an indicator of past exposure [US Environmental Protection Agency, 1992; ATSDR, 1995; ATSDR, 1996].

To obtain biomarker exposure data, a registered nurse drew 20 ml of blood from each participant during the home visit. The specimens were stored in sterile Vacutainer tubes, and taken to a laboratory in The University of Texas M.D. Anderson Department of Epidemiology for serum separation and centrifugation at 1,300 rpm for 10 min. Four milliliters of serum from each sample was refrigerated until mailed by next day delivery to Accu-Chem Laboratories in Richardson, Texas (referent laboratory). In this study, we compared the serum (ppb) concentration levels for various OCP metabolites (DDE, mirex, trans-nonachlor, β-BHC, δ-BHC, oxychlordane, and λ-chorldane) and also the total serum concentration levels of the study population to the Accu-Chem Laboratories' population average (referent laboratory).

The analytical procedure used in this study [Dale et al., 1966] incorporated standards and recoveries for 21 polychlorinated pesticides: α-chlordane, λ-chlordane, oxychlordane, heptachlor, heptachlor epoxide, mirex, trans-nonachlor, α-BHC, β-BHC, δ-HCH, aldrin, endrin, dieldrin, hexa-chlorobenzene (HCB), endosulfan sulfate, endosulfan II, methoxychlor, p,p′-dichlorodiphenyl-trichloroethane (DDT), p,p′-dichlorodiphenylchloro-ethylene (DDE) and DDD. OCP levels were determined using high-resolution gas chromatography with electron capture detection following an OC-specific cleanup of the lipid fraction of the serum. Lipids were extracted with methanol-ether-hexane and passed through Florisil and C-18 solid-phase extraction column to enrich a fraction with the compounds of interest. Appropriate internal standards were used for recovery and for quantification (octachloro-napthalene, dichloronapthalene, and aldrin). High resolution (HR) capillary columns were used to improve specificity and limit of detection. Serum lipids were also used, in addition to serum volume, for quantifying OCP concentrations. This provided an adjustment for normal intra-individual variation (10–20%) in serum concentrations of OCPs which can arise from fluctuations in serum lipids. The lipid adjustments were made using serum cholesterol and triglycerides that were performed on an aliquot of serum. The detection limits for individual OCPs were 0.3 ng/ml based on 1,200 samples analyzed by Accu-Chem (Dr. John Laseter, Toxicologist and Director of Accu-Chem Laboratories, Richardson, Texas, 1998. Personal communication).

We conducted Pearson's corrected χ^2 tests to compare differences between discrete variables (sociodemographics, self-reported pesticide exposure, living and work practices), and Student's *t*-tests to compare the mean differences in the OCP serum levels among study subjects (Fisher *P*-value used for ≤ 5 cells). We used SPSS for Windows® Statistical Software Program to conduct all the statistical analyses. We estimated total concentration serum OCP levels among study subjects as the sum of DDT + DDE + mirex + trans-nonachlor + λ-chlordane + oxychlordane + α-BHC + β-BHC.

RESULTS

Selected Characteristics of Study Population

As described in Table I, the majority of the MA migrant farmworker population included in this pilot study were female (69%), with a mean age of 45.4 ± 11.9 years, Mexican born (73%), residing in the US an average of 25.7 ± 15.0 years, and predominantly Spanish speaking (54%). The majority of study subjects were obese, with an average BMI of 30.8 ± 6.2 (obese BMI ≥ 30), had worked mostly in the US for an average of 5.1 ± 2.5 months per agricultural season, with a lifetime farmwork history totaling 9.4 ± 6.8 years.

TABLE I. Selected Characteristics of Study Population (N = 26)

Selected characteristics	Study population
Gender	
Males	8
Females	18
Age, years ± SD (range)	45.4 ± 11.9 (27–67.4)
Country of Birth	
Mexico	21
US[a]	7
Years residing in US ± SD (range)	25.7 ± 15.0 (2–58.1)
Language spoken	
Spanish only	14
Spanish and English	12
Body Mass Index (range)	30.8 ± 6.2 (22.3–48.7)
Country of work	
US	14
US and Mexico	12
Number of months worked per season (range)	5.1 ± 2.5 (1.5–7.8)
Number of years worked (range)	9.4 ± 6.8 (1–28)

[a]The Río Grande Valley, Texas.

OCP Serum (ppb) Levels in the Study Population Compared to Accu-Chem Laboratories Population

Table II compares the measured serum concentration (ppb) levels for various OCP metabolites (DDT, DDE, mirex, trans-nonachlor, β-BHC, δ-BHC, oxychlordane, and λ-chorldane) and the total serum concentration (ppb) levels obtained in our study population to the Accu-Chem Laboratories' population average (referent laboratory).

The mean total OCP concentration for the study population was 17.0 ± 15.5 (ppb). We detected three OCPs (DDE, mirex, trans-nonachlor) in most of the samples tested. The average serum level for DDE was 15.4 ± 17.2 (ppb), almost five-times higher than the Accu-Chem population average of 3.2 (ppb) based on more than 1,200 samples tested (Dr. John Laseter, personal communication). Fifty-eight percent of the study population tested positive for mirex (1.8 ± 0.6 ppb), despite this compound being banned in the US since 1978 [US Environmental Protection Agency, 1992; ATSDR, 1996] and Accu-Chem Laboratories did not detect this pesticide in their sample population. An average of 0.7 ± 0.6 (ppb) trans-nonachlor was detected in 35% of the serum samples tested (Accu-Chem obtained < 0.3, non-detectable level). DDT was measured in 12% of the participants' serum samples tested [1.0 ± 1.0 (ppb)], even though this OCP was banned in the US in 1972 [US Environmental Protection Agency, 1992; ATSDR, 1996]. Traces of two other types of OCPs were measured in 12% of the serum samples tested [β-BHC + δ-BHC + λ-chlordane + oxychlordane levels = 1.0 ± 0.8 (ppb)].

Work Practices

Table III summarizes the work practices of the study population, including country where agricultural work was performed, total number of years worked, number of duties (clearing field, planting, applying pesticides, harvesting, packing), work attire, and protective equipment worn. Respondents (54%) who worked only in the US exhibited higher serum concentration levels [19.0 ± 21.0 (ppb)] than those who worked in both countries [14.3 ± 13.8 (ppb)]. Participants who were born in the US and solely worked in the US had higher total OCP serum concentration levels [34.0 ± 26.6 (ppb)] than the participants who were born in Mexico and worked in both countries [13.6 ± 13.4 (ppb); $P < 0.05$], even after adjusting for age.

Migrant farmworkers who had worked longer than 5 years [50%, 23.4 ± 11.2 (ppb)], or who had performed two

TABLE II. Organochlorine Pesticide Serum Levels Among Migrant Farmworkers Compared to Accu-Chem Laboratories' Population*

Populations	Total OCPs[a] (ppb)	DDE (ppb)	Mirex (ppb)	Trans-nonachlor (ppb)	DDT (ppb)	Other OCPs[b] (ppb)
Migrant farmworkers						
Mean	17.0	15.4	1.8	0.7	1.0	1.0
SD	15.5	17.2	0.6	0.6	1.0	0.8
Detection limit		< 0.3	< 0.3	< 0.3	< 0.3	
Maximum	77.2	74.3	2.6	2.1	1.0	1.2
Detected specimens (%)	100	100	58	35	12	12
Accu-Chem						
Mean*	3.2	3.2	< 0.3	< 0.3	0.4	< 0.3/0.4

*Source: Information derived exclusively from the average of 1,200 samples tested by Accu-Chem Laboratories.
[a]DDT + DDE + mirex + trans-nonachlor + β-BHC + δ-BHC + oxychlordane + λ-chorldane.
[b]β-BHC + δ-BHC + oxychlordane + λ-chorldane. Population means for δ-BHC, oxychlordane, and λ-chorldane < 0.3 and 0.4 for δ-BH.

or more agricultural duties [65%, 19.7 ± 20.2 (ppb)] had higher serum levels than their counterparts. We compared serum levels by type of work attire, and found that farmworkers with greater potential for dermal exposure had approximately twice the serum levels of OCPs [''short-sleeved shirts'' 41.0 ± 25.6 (pbb) versus ''long-sleeved shirts'' 12.5 ± 12.5 (ppb); ''one pair of long-pants'' 17.3 ± 18.1 (ppb) versus ''two pairs of long-pants'' 8.0 ± 0 (ppb); and ''sneakers or shoes'' 18.6 + 18.9 (ppb) versus ''boots'' 7.4 ± 5.1 (ppb)].

TABLE III. Work Practices and Mean Serum Concentration Levels of Organochlorine Pesticide Metabolites Among Migrant Farmworkers (N = 26)

Work practices	#	Mean serum levels (ppb)
Country of work		
US only	14	19.0 ± 21.0
Mexico and the US	12	14.3 ± 13.8
Number of years worked		
≤ 5 years	13	15.7 ± 4.7
> 5 years	13	23.4 ± 11.2
Number of duties[a]		
1	9	11.6 ± 11.6
≥ 2	21	19.7 ± 20.2
Type of shirt[b]		
Short-sleeved	4	41.0 ± 25.6
Long-sleeved	22	12.5 ± 12.5
Number of pants		
One	24	17.3 ± 18.1
Two	2	8.0 ± 0.0
Footwear		
Sneakers or shoes	22	18.6 ± 18.9
Boots	4	7.4 ± 5.1
Protective wear		
Hats only[c]	12	25.1 ±23.0
Bandanas and hats	5	12.9 ± 8.6
Gloves and hats[c]	9	8.2 ± 6.2

[a]Include clearing the fields, planting, pesticide application, harvesting and packing.
[b]$P \leq 0.01$ (short vs. long-sleeved shirts).
[c]$P < 0.05$ (hat vs. gloves and hats).

All participants reported wearing ''hats'' only or in combination with other forms of clothes (''gloves'' or ''bandanas'') when conducting their agricultural work. Statistically significant differences in exposure levels were observed in migrant farmworkers who wore ''gloves and hats'' [8.2 ± 6.2 (ppb)] when compared to migrant farmworkers who wore ''hats'' only [25.1 ± 23.0 (ppb), $P < 0.05$]. Wearing ''gloves and hats'' [8.2 ± 6.2 (ppb)] when conducting farmwork appeared to reduce pesticide exposure more than wearing ''hats only'' [25.1 ± 23.0 (ppb)].

Table IV shows the living conditions and the self-reported pesticide exposures of study participants. All the statements included in this section (10/10) were positively associated with the levels of pesticides using a Likert-type scale (*never, seldom, half of the time, most of the time, always*).

Living Conditions

High levels of exposure were observed among participants who ''always ate their foods from the fields without washing it'' [24.6 ± 30.9 (ppb)], ''never washed their hands before urinating or going to the bathroom'' [18.0 ± 18.7 (ppb)] or ''showered or bathe daily after working in the fields'' [18.0 ± 8.7 (ppb)]. Low pesticide exposures were measured among participants who ''always washed their hands before urinating or going to the bathroom'' [7.6 ± 5.2 (ppb)] or ''showered or bathed daily after working in the fields'' [8.1 ± 1.7 (ppb)].

TABLE IV. Living Conditions, Self-Reported Pesticide Exposures, and Mean Serum Levels of Organochlorine Pesticide Metabolites Among Migrant Farmworkers (N = 26)

Characteristics	#	Mean serum (ppb) levels
Living Conditions		
How often did you...		
Sleep in a house away from the fields or orchards?		
Never/seldom	—	—
Half of the time	11	17.1 ± 21.0
Most of the time/always	15	16.6 ± 16.0
Changed clothes after work before entering living quarters?		
Never	23	17.5 ± 18.9
Seldom/half of the time/most of the time	—	—
Always	3	11.2 ± 3.7
Washed hands before urinating or going to the bathroom?		
Never/seldom	23	18.0 ± 18.7
Half of the time	—	—
Most of the time/always	3	7.6 ± 5.2
Shower or bathe daily after working in the fields?		
Never/seldom/half of the time	—	—
Most of the time	23	18.0 ± 18.7
Always	3	8.1 ± 1.7
Eat food from the fields without washing it?		
Never	21	15.0 ± 13.7
Seldom/half of the time/most of the time	—	—
Always	5	24.6 ± 30.9
Self-reported pesticide exposures		
During any of your work with crops, did you ever...		
Apply pesticides?		
Yes	3	38.5 ± 16.8
No	23	15.6 ± 17.0
Clean or come in contact with pesticide containers/equipment?		
Never/seldom	22	15.6 ± 15.5
Half of the time	4	24.2 ± 20.9
Most of the time/always	—	—
Worked in fields been sprayed with pesticides or soon after?		
Never/seldom	10	12.1 ± 11.5
Half of the time	—	—
Most of the time/always	16	20.0 ± 20.7
When in the field...		
How did you know pesticides had been applied?		
Strong smell[a]	12	8.8 ± 7.0
Airplanes fumigated over me[a]	11	21.0 ± 22.2
Applied pesticides	3	38.5 ± 16.8
Have you ever...		
Used pesticide inside your home or garden?		
No	6	12.7 ± 14.3
Yes	20	18.2 ± 19.0

[a] $P < 0.001$ (strong smell vs. airplanes fumigated over me).

Self-Reported Pesticide Exposures

Respondents (12%) who ‘‘applied the pesticides’’ and who also‘‘knew pesticides had been applied’’ exhibited high levels of pesticide exposure [38.5 ± 16.8 (ppb), Table IV]. Low levels were observed among respondents (46%) who ‘‘knew that pesticides had been applied because of a strong smell’’ [8.8 ± 7.0 (ppb)]. The rest of the self-reported pesticide exposure statements ranged in the mid pesticide exposure levels from 12.1 ± 11.5 (ppb) among respondents who‘‘never or seldom worked in the fields been sprayed with pesticides or soon after’’ to 24.2 ± 20.9 (ppb) in responents who ‘‘half of the time cleaned or came in contact with pesticide containers or equipment.’’

DISCUSSION

This pilot study conducted in the Houston Metropolitan Area (Baytown, Texas), found high levels of combined OCPs in the serum of MA migrant farmworkers. Migrant farmworkers of similar ages who conducted farmwork in the US only exhibited higher OCP serum concentration levels than those who worked in Mexico and the US. This may be explained by the percentage of US born migrant farmworkers who only conducted farmwork in the US, and who were born and raised in the highly agricultural areas of Hidalgo and Cameron counties, Texas (The Río Grande Valley region) where pesticides have been applied for many years.

The total OCP concentration levels of the migrant farmworkers increased with the number of years they worked as farmworkers to almost double among those who had worked for more than 5 years. It has been known that OCPs accumulate in adipose tissue over time [ATSDR, 1996]. Therefore, the type of body composition may be a major factor (majority of study participants were obese ≥ 30 BMI) for the observed pesticide residues in the blood serum.

In addition to the number of years worked, other variables related to an increase level of exposure probably reflect the potential for dermal exposure, such as type of clothing, protective equipment used, living conditions, and changing work clothes before entering living quarters. For example, wearing gloves while conducting farmwork can protect the hands from contaminated soil and crops or pesticides being applied. Many participants also stated that airplanes frequently sprayed the fields as they worked, and wearing hats and gloves appeared to be protective for exposure by holding back hair which can reduce the frequency of contaminated hands or gloves touching the face to push hair back.

All the study participants conducted agricultural work in the US, but almost half of them also worked in Mexico. Therefore, it is possible that the OCP exposure levels observed in this study could have originated in either country. For persistent compounds (OCPs), exposure assessment by questionnaires can be validated by measuring these pesticides in the blood serum since levels can be detected long after exposure. A greater problem exists when assessing the exposure of non-persistent compounds (organophosphate pesticides) because they do not remain in the body long after exposure (short half-life). It is worth mentioning, that even those migrant farmworkers who reported the least amount of exposure; the best living conditions, and the best work habits in this pilot study had higher levels of OCPs than the Accu-Chem Laboratories’ reported population mean averages.

In conclusion, due to the small number of study participants in this pilot study and their homogenous ethnicity, the results obtained in this study can not be generalized to the general migrant farmworker population in the US. Nevertheless, the results indicate: (1) MA migrant farmworkers, especially those migrant farmworkers who were born and raised in The Río Grande Valley, Texas have elevated levels of OCPs, some of which have been banned for decades in the US; (2) occupational, epidemiological, and pesticide exposures reported on standardized *MFQ* questionnaire can be used as proxies to estimate work-related OCP exposure levels when biomarker data are not available; and (3) shows the feasibility of conducting occupational epidemiological studies among homebased MA migrant farmworkers.

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